LUBRICATION

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EDITORIALS

Is the address on your copy of *Lubrication* correct? Thousands of the names on our mailing list have been received in handwriting difficult to decipher, and in spite of every precaution errors are bound to occur. Your co-operation in notifying us of any mistakes or changes in address will be greatly appreciated.

Are your turbine oils giving satisfactory service? Whether your turbines are lubricated with ring oiling bearings, or with self-contained circulating systems, or whether you have installed a turbine oil filtering system, Texaco turbine oils constitute the last word on the subject. These oils readily separate from water without forming an emulsion, and are manufactured to meet the severe service conditions encountered in turbine work. They are recommended by leading turbine manufacturers. Texaco Cetus Oil is the light, Texaco Alcaid Oil the medium, and Texaco Algol Oil the heavy turbine oil. For extraordinary conditions we have an extra heavy oil called Texaco Ursa Oil, which is used in the United States Navy for turbines of the heaviest type. On many occasions we have called attention in *Lubrication* to tests made with Texaco Cetus Oil or to service rendered by Texaco Cetus Oil. In last month's issue, for example, we mentioned a case in which Texaco Cetus Oil ran in a turbine for two years and three months, and at the end of this run the oil was practically as good as new.

Texaco Motor Oil has met with so many triumphs that its success in the Oldsmobile Non-stop Run does not appear to us as being anything out of the ordinary. We might say, in fact, that we expected that Texaco Motor Oil would be in every way equal to the conditions, and so far as the motor oil is concerned the test might have been still running. It should be remembered, too, that this test was run under conditions which were more severe on the lubricants used than an ordinary road test.

THE LUBRICATION OF STEAM TURBINES

By The Lubrication Engineers Association of
The Texas Company*

DURING an engineering convention held some fifteen or twenty years ago in Pittsburgh, the delegates made a visit to the shops of the Westinghouse Machine Co. The interest of these engineers centered around a small Parsons turbine situated in the gallery of the main shop building. Mr. Geo. H. Westinghouse had been to England a short time previously and had procured the right to manufacture this type of turbine in the United States. The construction and operation of the machine were minutely explained by Mr. F. Hodgkinson, one of Mr. Westinghouse's associates in the early development of the turbine. This marked the entry of this type of machine into the list of prime movers in America, and so rapid has been the progress of the turbine that it has virtually displaced many of the engines representative of the best practice five or six years ago. Alternating current generators, blowers, marine propellers, turbo-compressors, and pumps are all being driven by steam turbines; and by means of reduction gearing they are utilized to furnish power for reciprocating air compressors, rolling mills, and other classes of slow speed machinery.

The reason for the favor with which the turbine has been received lies in the many distinctive advantages which it possesses. This machine, although composed of a relatively large number of parts as compared with a reciprocating engine of like capacity, possesses few moving parts and frictional surfaces. The absence of pistons, stuffing boxes, dash pots, and the like, reduces the cost of maintenance and attendance to a minimum, and limits the possibility of leakage. The floor space required by practically all types of turbines is considerably less than the space requirements of piston engines. A report upon efficiency tests of a 30,000 kw. cross-compound steam turbine revealed the fact that in the floor space occupied by a reciprocating engine of 5,000 kw. capacity, a steam turbine of 30,000 kw. rating had been installed, and the turbine unit was operated at a cost per kilowatt of approximately one-fifth of that of the original engine. The weight of the turbine is small in comparison with that of a piston engine of the same horse power. For this reason and owing to the freedom from reciprocating motion, the foundations required for turbines are of small size and light weight, there being little vibration to be absorbed under proper conditions of aligning and balancing. Turbine oil consumption is lower than the oil consumption of any other prime mover, the loss of oil being due chiefly to leakage and a small amount of evaporation. Since there is no internal lubrication the steam is not contaminated with the oil, and therefore the condensed steam is immediately avail-

*Editor's Note—Papers on this subject were submitted by the following members of the Association: Messrs. W. M. Davis, John H. Young, Jr., H. D. Gohlman, J. N. Prewitt, H. J. Wilson, J. D. Barton, W. O. Kroenke, W. A. Edmondson, H. W. Salbador, J. T. Snow, D. L. Keys, F. J. Davis, J. A. Hansgen, W. G. Craig, G. M. Shanks, S. J. Hunt, W. H. Grose, and Walter L. Foster.

Figure 1—Oiling Ring

able for boiler-feeding purposes without purification; and this re-use of condensed steam effects a large saving in cost of feed water and in expense for the maintenance and cleaning of boilers. Again, superheating imposes no restrictions in the choice of lubricant. Finally, the turbine can usually be started and loaded more quickly than the piston engine.

The rotating parts of the turbine proper are connected to and revolve with the shaft so that the bearings that support the main shaft are the only parts that require lubrication. These bearings are on either side of the turbine proper and are subject to radiated heat from the steam passing through the turbine.

Turbine lubrication is accomplished either by ring oilers or by some form of circulating system. Ring oiling bearings are used on small types of turbines, the rings dipping into a reservoir of oil and carrying the oil to the bearings to be lubricated. This method has been found satisfactory where the bearings are adjusted so that the rings do not vibrate and are free from sharp edges that may interfere with their free play, and, what is of still greater importance, where the reservoir into which the rings dip is of sufficient capacity to permit the oil to rest. Lubrication difficulties are sometimes experienced on certain types of turbines equipped with ring oiling bearings because of radiated heat. This affects particularly the governor bearing, which sometimes reaches a temperature as high as 240 degrees F. Figure 1 shows a channel oiling ring as used on the Sturtevant turbine.

Larger types of turbines are usually lubricated with a self-contained circulating system which cools and strains the oil before forcing it back to the bearings under pressure. The oil is used over and over again, the relative size of the oil system determining how frequently the same oil is fed to the bearings. With this oiling system the highest temperature is experienced on the governor bearing, the next highest on the inside turbine bearing, the inside and out-board generator bearing both being lower in temperature. The oil is in constant agitation, frequently with water which leaks past the packing glands, and unless the oil is a high grade turbine oil, the oil will emulsify. Sufficient oil must be added to the system from time to time to maintain the oil level, making up for the oil that is lost.

A section of a typical modern steam turbine, showing the self-contained oil circulating system is shown in Figure 2. Oil from the various bearings flows by gravity into reservoir (B), and a small rotary pump (A), usually driven

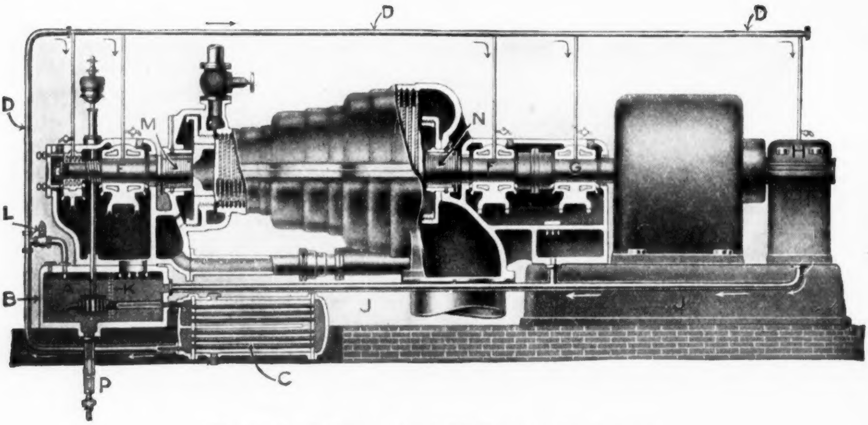


Figure 2—Self-contained Oil Circulating System

from the governor shaft, takes this oil and forces it through the cooler (C) and thence through pipes (D) to the various bearings. A spring relief valve (L) by-passes any excess oil back into the storage reservoir (B). In some systems instead of using a relief valve (L) the oil is discharged into an overhead reservoir and allowed to flow by gravity to the bearings. The turbine shown in Fig. 2 has four main bearings (E), (F), (G) and (H). These bearings are hollow and cooled by circulating water through them. The oil is fed into the top of the bearings at the center and flows out at each end. The oil then drops down into chambers in the turbine casing and is collected by the return pipe (J) and returned to the reservoir (B). A screen (K) is provided in the reservoir to remove any large particles of foreign matter.

There are several places where water finds its way into the oil, the main place being the packing gland (M), at the high pressure end of the casing. Turbine manufacturers employ various methods for preventing steam leakage at this point such as carbon packing held against the shaft by springs, labyrinth packing and water seals, but in spite of these precautions some steam always leaks out, travels along the shaft and, coming in contact with the water cooled bearing at (E), condenses and mixes with the oil. When turbines are operated on back pressure there is also an outward leakage of steam at the gland (N) on the other end of the turbine. Occasionally the cooler (C) or the hollow water cooled bearings will also develop small leaks, permitting water to get into the oil.

A drain cock (P) is provided in the bottom of the reservoir (B) for drawing off water which collects at this point, and which should be drained off regularly. As the oil passes so rapidly through this small tank there is not sufficient time for complete separation of the water, especially when it is considered that the water and oil are thoroughly churned in passing through the rapidly moving bearings. Furthermore, steam turbine bearings are usually run very hot, and the cooking process through which the oil passes in coming in contact with the leaking steam and hot water makes an intimate mix-

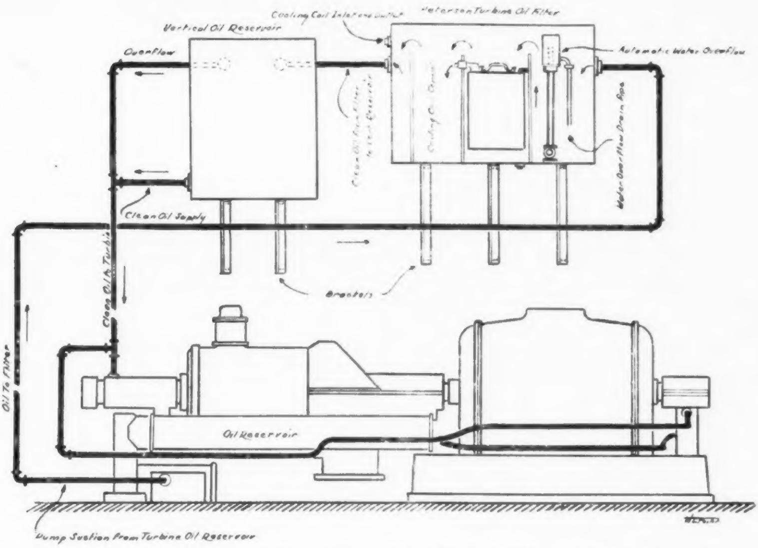


Figure 3—Turbine Oil Continuous Cooling and Filtering System

ture of oil and water. Taking these points into consideration it is evident that it is necessary to provide something more than the coarse screen (K) to thoroughly purify the oil.

Where a separate filtering system is used, considerably more oil is in circulation, the oil has more chance to rest, and the water and impurities in the oil are removed, thus prolonging the life of the oil. One of the important advantages of a filtering system in connection with the oil circulation system is the fact that it makes it possible to keep the cooler tubes clean. Unless a filtering system is used the dirt that forms in the oil, due to water and foreign matter and with some oils to oxidation on account of high temperatures, will collect on the coolest part of the turbine oil circulating system, which is the "cooler." As this dirt collects on the cooler, the walls will get thicker, and as the walls thicken their conductivity decreases, so that the full benefit of the cooling water is not realized. As that process goes on the cooling effect in time is lost, and oil will be circulating at a very high temperature. Moreover, dirt in the oil will eventually find its way to the bearings, and in time, if the water that collects is not taken out, a mixture of water and oil will be fed instead of oil.

Steam turbine oiling and filtering systems may be classified as follows:

1. Continuous circulating systems in which the oil used on the bearings is continuously passed through a system which filters all or part of the oil. In Figure 3 is shown a gravity cooling and filtering system as designed by the Richardson-Phenix Company for the lubrication of DeLaval turbines. Oil from the bearings is drained into the oil reservoir in the turbine, from which it is lifted to the filter by a pump geared to the turbine. The first filtering process precipitates the water, the oil overflowing into the filtering compartment. The speed of oil circulation is such that it would be impracticable to filter all

of the oil, but the heaviest and dirtiest portions are, by virtue of their greater weight, compelled to pass through the filter. The clean part escapes the filtering operation, but all of the oil is compelled to pass through the cooling coil compartment before it reaches the vertical oil storage tank, from which the lubricant is fed directly to the bearings. This vertical tank is placed immediately adjacent to the cooling compartment of the filter.

2. Batch filtration, in which all of the oil contained in a turbine oiling system is removed and purified, the turbine being supplied with a fresh batch of clean oil to permit it to operate while the dirty oil is being purified. With this system the oil in one turbine after another can be filtered and the oil from the clean oil compartment of the filter can be pumped into the turbine from which the dirty oil has been removed. This is the system ordinarily used where filtering systems have been introduced.

3. Partial filtration, which was described in an article in an earlier issue of *Lubrication,** and in which part of the dirtiest oil is continuously removed from the circulating system, passed through a filter and returned to the system by a steam pump, automatically controlled by the head of oil in the clean oil compartment. This system is now being installed, particularly in connection with Allis-Chalmers turbines.

In the forced feed system which has been used in the lubrication of Curtis Vertical Turbines, a tank large enough to contain all the oil, and fitted with straining devices and cooling coils, or connected with a separate filter, is situated at a suitable level for receiving oil by gravity from all points lubricated. The oil is drawn from this tank by a pump which delivers the oil at a pressure about twenty-five per cent. in excess of that required to sustain the weight of the turbine in the step bearing. A spiral duct baffle is situated between the source of pressure and the step bearing, and this regulates the oil supply and renders the flow more uniform. This source of pressure is also connected, through a reducing valve, to the upper oiling system of the machine, where a pressure of about sixty pounds to the square inch is maintained. This system, which includes a storage tank partly filled with compressed air, operates the hydraulic governor mechanism and supplies oil to the upper bearings. The regulation of oil to these bearings is effected by means of adjustable baffles. Drain pipes from the upper bearings and from the hydraulic cylinder and relief valve, all discharge into a common chamber in which the streams are always visible, so that the oil distribution can always be under observation.

Previous to the adoption of turbines, it was very generally believed that only fatty oils would emulsify with water, and that a mineral oil would separate from water, but it was soon discovered that the speed of the turbines was so great and the churning action so violent that a petroleum oil which was not properly manufactured would form a permanent emulsion with any water with which it came in contact.

As an illustration of a severe case of emulsification with a paraffine oil, the case of a lead mining and milling plant in Missouri a few years ago may be cited. This occurred in the lubricating system of two vertical Curtis turbines,

*"Turbine Oil Filtering Systems," by Edwin M. May, in *Lubrication*, Vol. III, No 11, September, 1916, p. 2.

fitted with a large Turner filter of several barrels capacity. The chief engineer complained that he had found it necessary to add several barrels of new oil to the system every month, and, since no leaks could be found, he was at a loss as to the cause of the rapid oil consumption. Upon careful examination it was found that the water in the filter and settling tank was milk white, and the engineer explained that he had to draw off the water several times a day to avoid an overflow. By way of explanation he opened the drain pipe and allowed some of the water to run off. A large glass jar was filled with some of this waste water, and after it had settled there was a layer of oil found on top of the water, and the water still remained a milk white color, indicating the presence of oil still held in suspension.

With paraffine oils the peculiar conditions encountered in the bearings and the system generally may cause a partial separation of the oil and paraffine, and the subsequent contact of the oil with the cooling coils of the system results in a deposit of the paraffine, thus interfering with the proper functioning of the coils.

In a previous issue of *Lubrication** the conditions which have to be met by a turbine oil were stated as follows:

"The demands made upon an oil in a turbine are exceedingly severe. The oil must circulate at high speed through innumerable valves, pipes, and bearings, subjected first to high and then to low temperatures, and to many variations in pressure. It is thoroughly mixed with air, so much so that foam is quite frequently found on top of the oil in the settling or sump tank. Air bubbles can always be seen as the oil flows from the bearings. Frequently it must operate with a percentage of water which leaks through the stuffing boxes, or, with water that leaks in from an imperfect or damaged cooler coil, or, in the case of marine installations, salt water can sometimes get into the system from overboard. At times the oil in the bearing in close proximity to the stuffing box is actually cooked by the live steam. The steam carries with it boiler impurities or chemicals used for boiler water treatment, and very often these chemicals in connection with the water and air cause the oil to form very bad emulsions. Any oil that has a tendency to form an emulsion is rather dangerous for use where the churning, heating, and boiling with water and boiler compounds are carried on to such an extent as in a turbine lubricating system.

"Much damage has been done to turbines because of the tendency of certain oils to emulsify. Some oils will throw down a hard emulsion which, under the conditions which prevail in the turbine, will cake in such a way as to actually stop up the pipes and oilways to the bearings. Other oils carry the water in suspension and are of such a nature that the water will drain off only with great difficulty. The best turbine oils, of course, are those that under all conditions will allow whatever water gets into them to drain off and will produce a minimum amount of emulsion, this emulsion being of such a nature that it will not form a hard deposit. The perfect oil is one of high lubricating body which will separate freely from any amount or any kind of water after it has been thoroughly agitated and even boiled and which will leave absolutely no permanent emulsion.

"Next in importance is the question of viscosity. At one time the American oil manufacturers used the very lightest distillates for turbine work, the theory being that these lighter oils separated easily from water and formed less objectionable emulsions. The factor of safety, however, was exceedingly small with these light oils. The many mechanical difficulties experienced while these low viscosity oils were in use resulted in the demand for heavier oils, until in some turbines doing very severe work, very heavy oils are now being used with complete success. The majority of turbines, however, can best be lubricated by a medium bodied oil such as TEXACO CETUS OIL."

The following extract from the Terry Steam Turbine Co.'s Instruction Book on Bearings and Lubrication indicates the attitude of the

*"Lubrication of Steam Turbines with Recommendations of Turbine Manufacturers," by W. F. Parish, in *Lubrication*, Vol. III, No. 10, August, 1916, p. 3.

turbine manufacturers on the subject of viscosity:

"Grades of Oil.

"The viscosity of the oil used in any case must be suitable for the service. We are listing below oils recommended by several refiners for turbine work, in three ranges of viscosity roughly classified as Light, Medium and Heavy. The approximate viscosity of each oil is given with its trade name. All viscosities are in seconds at 100° F. by Saybolt Universal Viscosimeter. These oils are tabulated for the convenience of the turbine user as being standard brands. If any oil named is found unsatisfactory for the purposes stated, please advise us for our information.

"(a) *Light* oil, viscosity 130 to 200 seconds, is best for turbines without reduction gears, either ring or forced feed oiling.

"(b) *Medium* oil, viscosity 200 to 350 seconds, is used for turbines *with Reduction Gears* and either ring or forced oiling. It is better than a light oil for turbines subject to vibration either from within or from an external source. It will also allow slightly greater bearing clearances. Bearings may run a few degrees warmer with heavy oil than with the lighter grades.

"(c) *Heavy* oil, viscosity 350 to 500 seconds, is useful in cases of bad vibration or of gears heavily loaded or causing noise. Many times gears can be successfully operated with heavy oil which would be noisy or show rapid wear with lighter oil. Heavy oil works well in turbine bearings except in places where exposure to cold sometimes makes the oil too sluggish. This applies especially to forced oiling units. When using heavy oil, more attention must be given to the oil when starting, to be sure that all rings run freely, and that bearings are not flooded by the forced oiling systems.

"The purpose of an oil is to form a film between the surfaces to be lubricated to minimize friction, and to act as a cushion or dash-pot to prevent vibration or pounding between the journal and the bearing or between adjacent gear teeth.

"The lightest oil that will do this with certainty will give the lowest running temperature and usually the lowest cost per gallon. The best oil for a particular unit depends on operating conditions to a large extent, but in general the SAFE AND ECONOMICAL oil to use is a grade slightly heavier than the lightest oil on which it will operate smoothly and quietly."

Maker	*Light*	*Medium*	*Heavy*
The Texas Company, 17 Battery Place, New York, N. Y.	Cetus Viscosity 180 to 200	Alcaid Viscosity 300 to 325	Algol Viscosity 500

(Three other turbine oils are also mentioned in this Instruction Book.)

In the August, 1916, issue of *Lubrication* the turbine oil recommendations of the Westinghouse Machine Co. and Allis-Chalmers Mfg. Co. were given. The following is quoted from the instructions of the Westinghouse Machine Co. to their erecting engineers:

"So far as mere lubrication of the turbines is concerned, almost any oil at all has lubricating properties sufficient for the bearings to run cool, so that the fact of the bearings running cool and nice is no criterion of the suitability of the oil.

"A large quantity of oil is in circulation in the turbines at a temperature of from 100° to 120°, or thereabouts, which temperature is conducive to any chemical reaction, should the necessary elements be present. It is therefore important that the oil be an absolutely pure mineral oil, free from acid. Sometimes mineral oils are adulterated with animal fats, which will in the course of time decompose, forming acids, corroding the shaft, and even eating up the bearing metals."

The following is quoted from the recommendations of the Allis-Chalmers Manufacturing Company:

"We have found it generally true in steam turbine lubrication that, while one oil may be suitable in the majority of cases, there are, from time to time turbines that seem to require either a heavier or a lighter oil and this makes it inadvisable to issue a fixed specification governing this one class of work.

"A suitable oil for the lubrication of steam turbines must have certain general characteristics which, in the order of their importance, are as follows:

"The oil must be so made and of such a nature that it will separate freely from water, and that water of any nature or any temperature being agitated with the oil in any amount will not form an emulsion; even if the conditions require the oil and water to work together so that a mechanical mixture of the oil and water is secured, the combination must not be permanent, but upon resting and being subjected to a heating temperature of not over 175° F., the water must separate. Preference should always

be given to the oil separating the most quickly after being agitated with water that will be used for boiler purposes at the plant where the turbine is located. Tests should be made by shaking 50% of oil and 50% of water in a bottle or by mechanically stirring this mixture in a suitable container for, say ten minutes, and noting the separation of water after ten minutes and after twenty-four hours.

"Any oil that in the above tests, or in practice, will throw down a deposit, should under no conditions be used for turbine lubrication, as this deposit may under severe conditions interfere with the flow of the oil to the bearings.

"Oil in order to meet the above conditions, must be free from acids, free from all fixed oils such as vegetable and animal oil, and should be properly refined.

"The leading manufacturers of lubricating oil have introduced the practice of determining a property known as "viscosity." To determine the body or viscosity of an oil a standardized viscosimeter is used, by means of which the time occupied in the flow of a measured quantity of oil through a small orifice at a given temperature is measured. The Saybolt Universal Viscosimeter is commonly used for this purpose by the large producers and refiners of lubricating oil in this country, the sample of oil being maintained at a temperature of 100° F. and the time occupied in the flow of the measured sample of oil through a small orifice being measured in seconds. This time reading represents the relative viscosity of the oil which, in the majority of cases for steam turbine lubrication, should be about 200 seconds at 100° F. Saybolt Universal.

"Should it be desired to operate the turbine with a very slight reduction in temperature of the bearings, oil as light as 150 seconds viscosity for the majority of turbines can be used. On the other hand, should the mechanical conditions require oil of heavier body, an oil as heavy as 750 seconds at 100° F. Saybolt machine, can be used. All of these oils, however, irrespective of the body or viscosity, should conform absolutely to the separation from moisture or water tests. All other tests, such as gravity, flash, fire and color, have no bearing whatever for this class of lubrication, but it might be well to be more explicit in regard to these particular tests. . . .

"The temperature of a bearing in a turbine working on a forced feed system is in proportion to the viscosity or body of the oil; that is, if a very heavy bodied oil is used, the partially resulting bearing temperature can be reduced to certain limits by the use of a lighter bodied oil. There is a limit to the lightness of the oil, which, in the majority of cases, should not be less than 150 seconds viscosity on the Saybolt Universal machine. The temperature of a turbine bearing, however, is not a point of the greatest value in turbine lubrication. The oil heavy in viscosity has the very valuable feature of staying on the surface of the bearing after the turbine has come to rest, so that in starting, the surfaces are well lubricated. Further, heavy bodied oils will take up bigger clearances and operate with rougher bearings and shafts without danger, whereas, under these abnormal conditions, light bodied oils would invariably lead to trouble, as the oil would not have sufficient thickness of film to keep the high points of the surfaces apart.

"The actual mechanical frictional difference, or the effect upon the mechanical efficiency of the turbine, between the use of a heavy and a light oil on a turbine having two or three bearings is infinitesimal.

"Water is the main deteriorating element to the life of a turbine oil, therefore, special attention should be given to keep water out of the circulating systems and out of all filters. The system should be a dry one, and daily inspection should be made to see that water is not getting in. The oil that will meet the water test can be used indefinitely in a turbine by being added to from time to time.

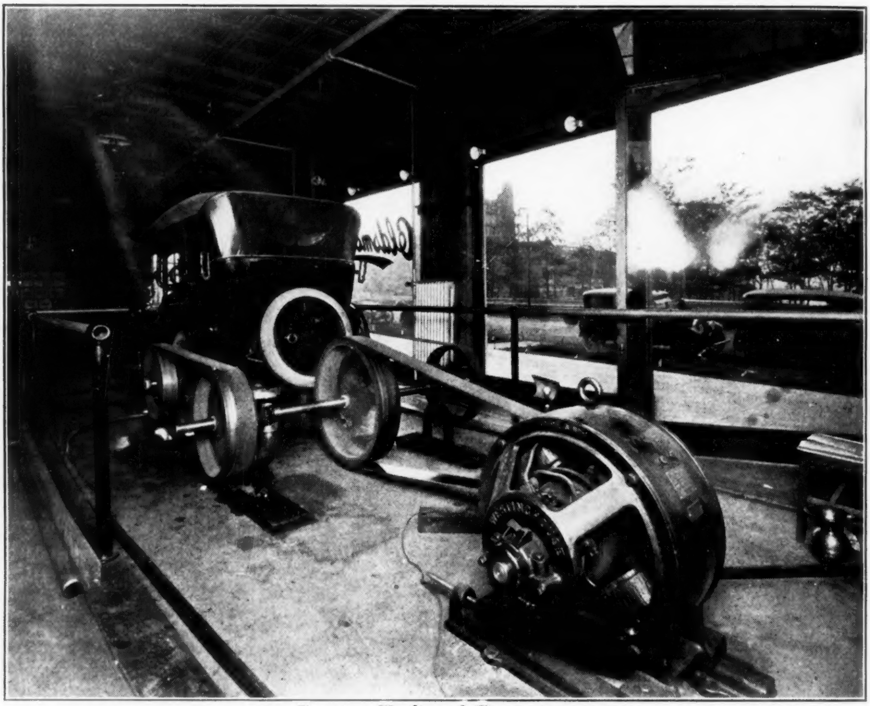
"The following list of oils which have been used in our steam turbines and found satisfactory, is to be submitted by you, without recommendation, to any of our customers who request information regarding the kind of oil to be used in our steam turbines; the selection of the particular brand to be left to them . . . . ."

(Signed) L. E. Strothman, Manager,
Steam Turbine Department.

The Allis-Chalmers Company lists six turbine oils, of which TEXACO CETUS OIL is one.

OLDSMOBILE NON-STOP RUN

ALL non-stop automobile records have been shattered by a Model 37 Oldsmobile Six, lubricated with Texaco Motor Oil. The run was started on May 21st at 9.30 A. M. by Mayor Curley of Boston, and the engine was not stopped until July 7th, a continu-



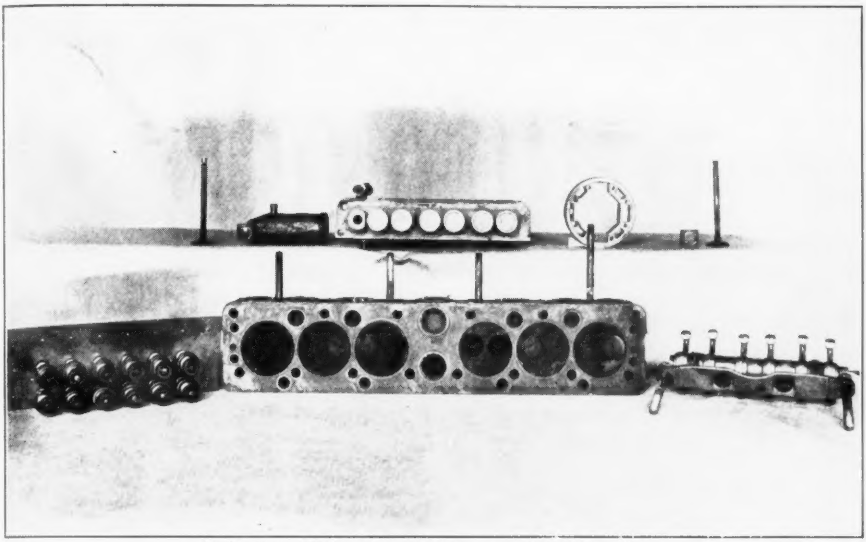
Counter Shaft and Generator

ous run of 47 days, or 1,128 hours. During this period the car covered the equivalent of 26,149.3 miles at the rate of approximately 22.5 miles per gallon of gasoline, and 950 miles per gallon of oil.

This test was made with the car fastened by means of steel straps to a temporary frame, the wheels being clear of the floor. The rear wheels were belted to a counter shaft, and this in turn belted to a 17 kw. D. C. dynamo, which furnished the power for all the lights inside and on the face of the building. The number of lights carried by the dynamo constituted a load equivalent to the car climbing a 10% grade at about 22 miles per hour on high gear. The load at the board was 70 amperes at 120 volts, or 11.3 horse power, and an additional load, estimated at 8 or 9 horse power, was calculated as the energy consumed in the transmission of power from the car to the generator. The run was made in the show windows of the Oldsmobile Company of New England.

The engine was lubricated by means of a splash system, the connecting rod dippers sweeping through individual drains in the crank case. The oil level was maintained by a single plunger pump inside of the crank case and driven by an eccentric on the cam shaft.

The following Texaco products were used on this run: TEXACO auto gasoline for fuel, TEXACO Motor Oil for engine lubrication, TEXACO Ursa Oil for the transmission, and TEXACO Thuban Compound for the differential. TEXACO Ursa Oil was used in the transmission instead of TEXACO Transmission Grease, because the long bronze bush bearing which



Cylinders, Valves, Spark Plugs, and Timing Gear

carried the counter shaft for driving the dynamo received its oil from the transmission case.

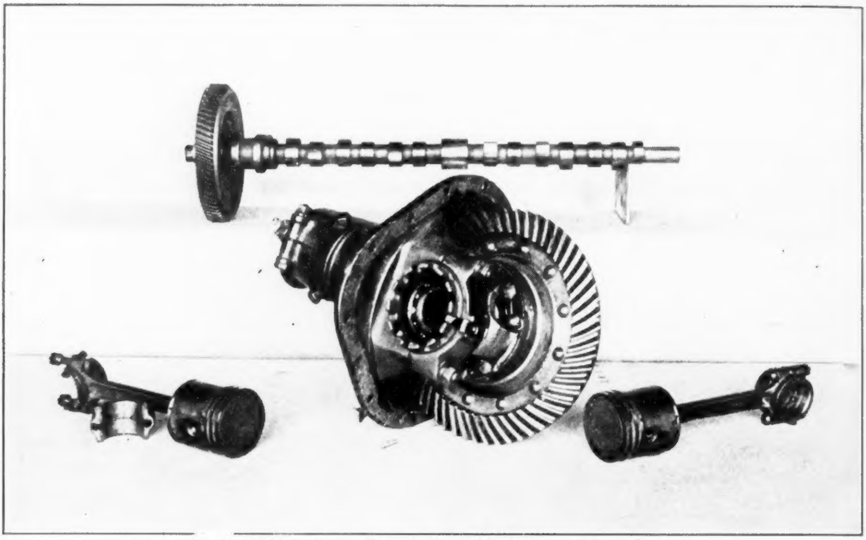
The Texas Company had an engineer on this test almost daily, and the reports that came through indicate that the lubrication was very satisfactory and that those in charge of the test were more than pleased with the way Texaco products, particularly TEXACO Motor Oil and TEXACO Thuban Compound, handled the severe conditions.

Whatever may be said about the relative merits of a block test as compared with a road test, it is evident that the lubrication conditions were much more severe on this run than would have been the case on an ordinary road test. It should be recalled that the engine was never stopped for a moment during the whole 1,128 hours, and that during all of this time the engine was operated at practically full load with an extraordinary strain on the differential.

On the seventh day our engineer made the following report: "It has been noted from time to time that the engine's exhaust is very clear, indicating proper combustion, and also the absence of lubricating oil from the cylinders other than that required to furnish necessary lubrication for piston rings and cylinder walls. The absence of gasoline fumes from the oil drawn from the crank case indicates that the oil is maintaining a perfect seal around the pistons."

On the ninth day the engineer reported that no spark-plug trouble had developed up to that time, which was remarkable as the car had covered nearly 5,000 miles. This indicated that whatever motor oil had reached the cylinders was burning freely and passing off with the exhaust without leaving appreciable carbon deposits.

On the twelfth day one spark plug was removed and was found in perfect condition. The point was entirely free from carbon and there was no indication of the points being fused. Some carbon, however, was found around the collar, but this was to be expected since the temperatures are the



Differential Gear, Cam Shaft, Pistons and Bearings

highest at this point, and the combustion gases do not carry off the carbon deposits from this place.

On June 5th all of the spark-plugs were removed, one at a time, and replaced with new ones. The condition of the plugs was exceedingly good. The absence of carbon was particularly notable and caused no little comment from those who inspected them.

On June 10th, the twenty-first day of the run, it was reported that the TEXACO Motor Oil Heavy was giving exceptionally good results and that the Manager and the Assistant Manager of the Oldsmobile Company had many times expressed satisfaction at the results obtained. The Thuban Compound in the differential was meeting all expectations, and the transmission case up to that time had not required additional oil.

Mr. Lowd, the assistant manager, paid the following tribute to the quality of TEXACO gasoline and lubricants, which we quote from a Boston paper: "We haven't yet filled a single grease cup and the lubrication has been perfect ever since the start. When one considers that this test was made with a 'stiff' motor, one just received from the factory without any preliminary run other than the standard factory test, this feature is especially interesting. The gasoline consumption shows that there is a good harmony between the motor and the gasoline it consumes, while the oil consumption is 'way below the average for most six-cylinder cars."

"Our salesrooms have been crowded night and day by critical motorists who have carefully checked up every reading. They are a unit in declaring that we will easily exceed all previous non-stop run records with hours to spare. After we have smashed them all to a fare-you-well, we intend to pull the entire car to pieces and submit it to exhaustive tests by a corps of experts from Technology, Worcester Polytechnic Institute and other engineering institutions, to see just what wear, if any, has occurred during the run. And I think they will surely need their micrometers to find any."